An Approach to Model the Environmental Risk of Aquaculture Drug Use

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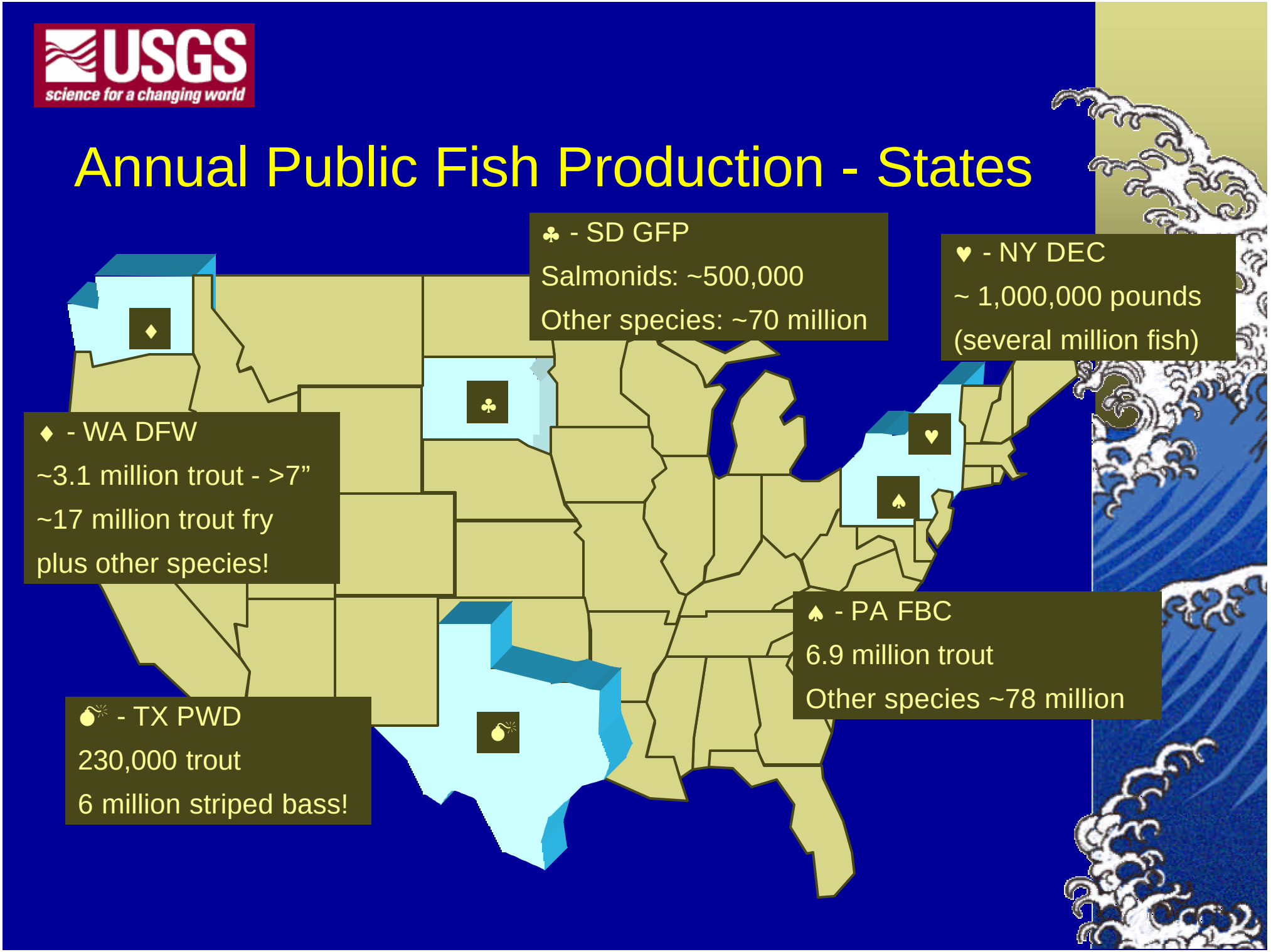
Love at first gill!

A father’s work is never done!

Guarding the brood!

Lets eat!

Annual Public Fish Production - States



Annual Public Fish Production - FWS

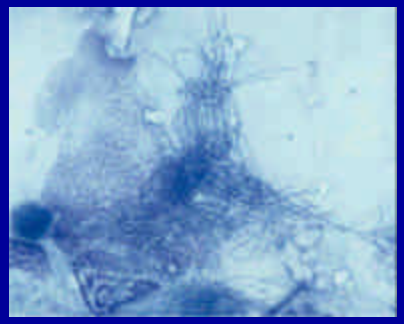
85 million salmonids

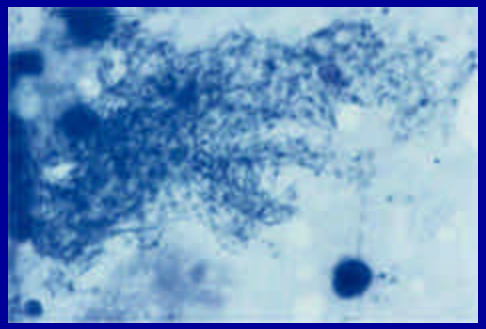
7400 mussels

49 million others – sportfish and endangered

Fish disease at hatcheries

- *External diseases*





Bacteria

Fungi – water molds

- *Contact microbicides – hydrogen peroxide, formalin chloramine-T, $CuSO_4$, $KMnO_4$*

Parsites

Fish disease at hatcheries

- *Systemic bacterial diseases*

- *Oral drugs – medicated feeds*

Drug approval process

Environmental Safety

Human Food Safety

Target Animal Safety

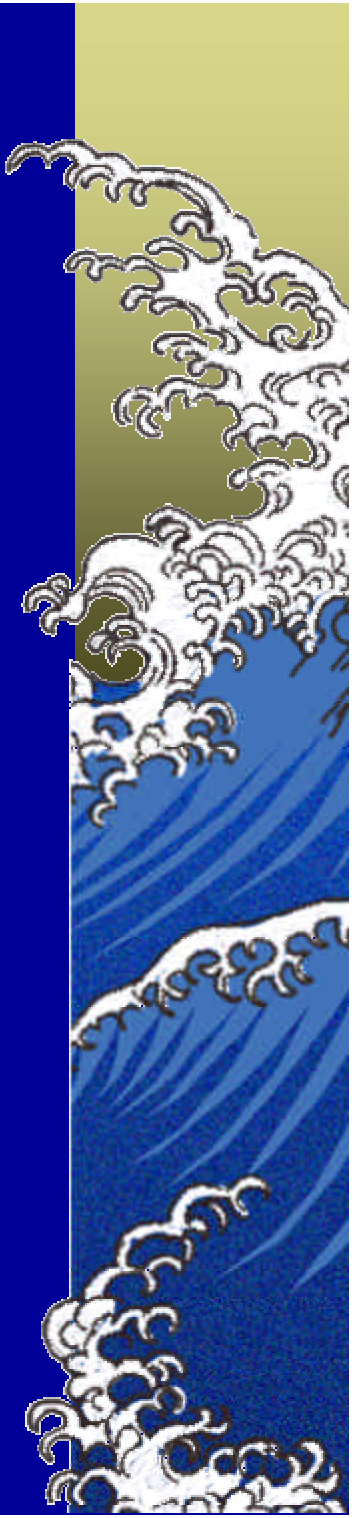
Efficacy

Mammalian Toxicology

Product Chemistry

ES Issues for Aquaculture Drugs

- *Drug Application – How, where, when, how much*
- *Drug Discharge – How much, duration, degradation, degradation products*
- *Environmental Fate – Degradation, transport, sediment vs. dissolved*
- *Environmental Effects – What is the risk of acute or chronic effects (Risk assessment)*



Data Gap → Hatchery data

Drug Application

Where *How*

When *How much*

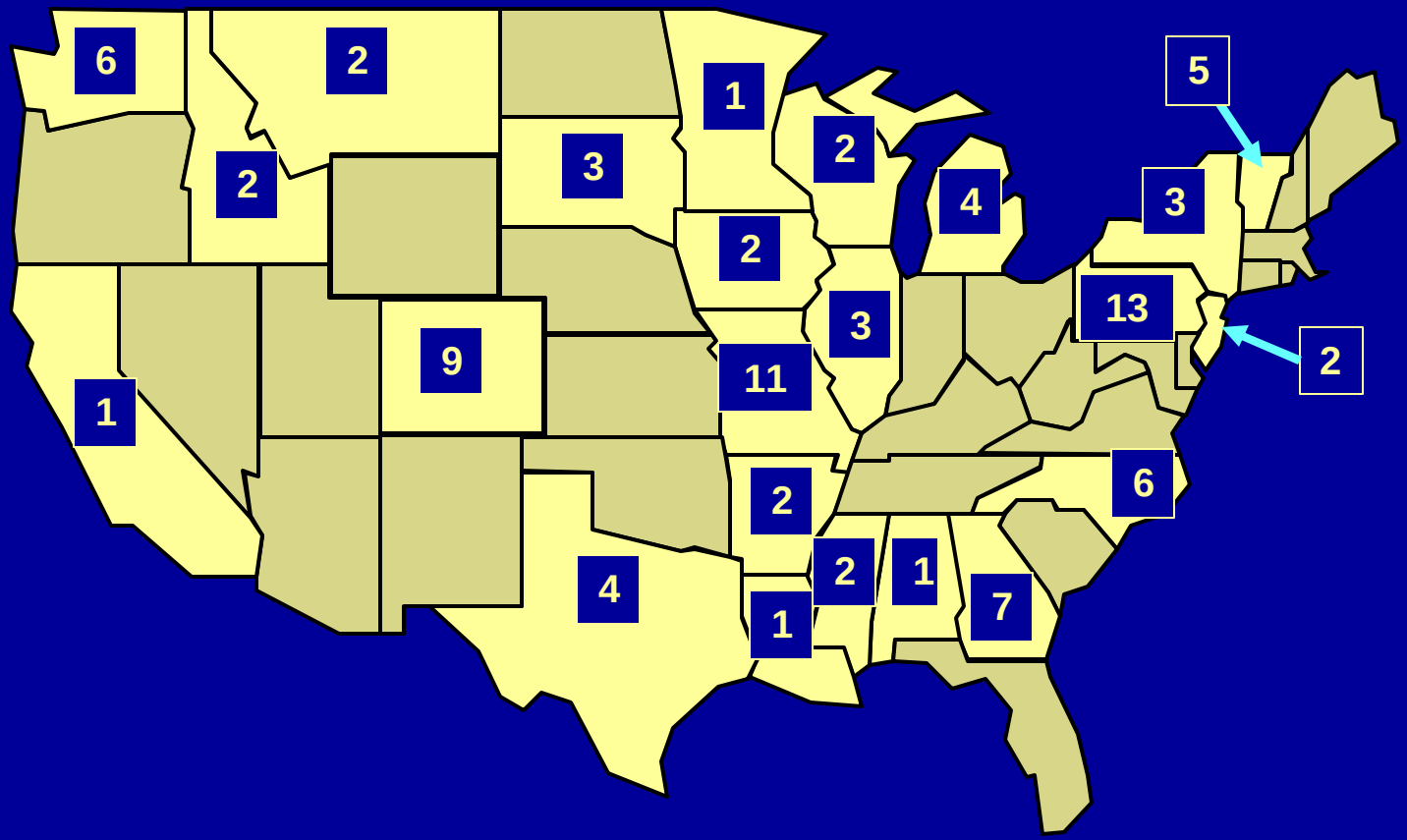
Drug Discharge

Hatchery flow *Duration*

Receiving water *Effluent treatment*

- *Lake, river, backwater*
- *Fresh, backish, salt*
- *Settling or detention pond*
- *Filtration, etc.*

Hatchery survey response



100 Public and Private facilities!

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Hatcheries – A diverse bunch








Now that we have the data, ???

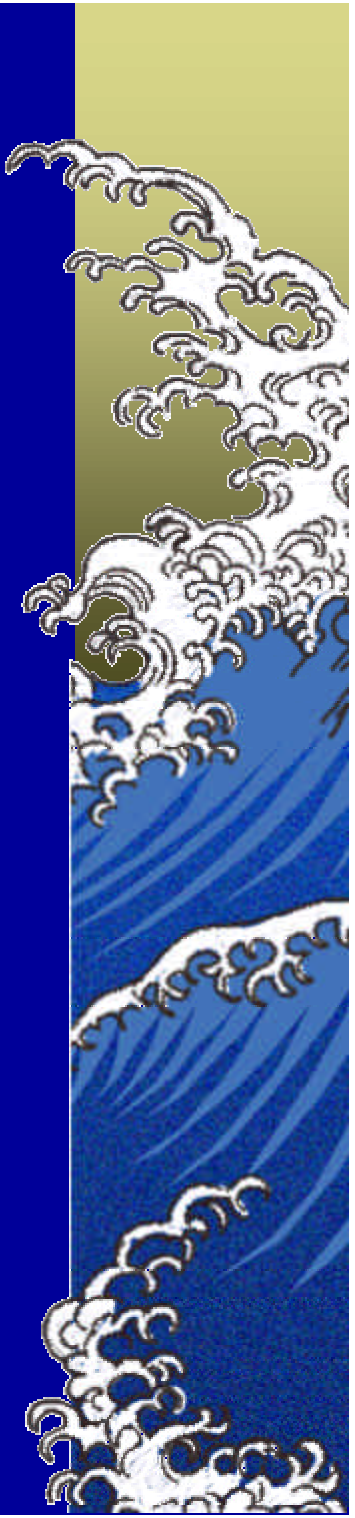
- *How do we estimate the discharge concentration?*
  - *at the pipe (Environmental Introduction Concentration)?*
  - *or in the receiving water body (Estimated Environmental Concentration)?*
- *How do we summarize the range of potential discharges in our risk assessment?*
  - *Mean?, Median?, upper 95% CI? – what is representative?*

Chloramine-T, a case in point

- *Safe, effective, waterborne, contact microbicide.*
- *Administered as static or continuous flow immersion bath for up to 60 min.*
- *Maximum dose is 20 mg/L.*
- *Detected as total residual chlorine in EPA approved methods.*

Chloramine-T continues

- *Decided to estimate Environmental Introduction Concentrations (EIC), the in-pipe concentration.*
- *Calculation assumptions*
  - *No degradation*
  - *Maximum dose – 20 mg/L*
  - *Continuous-flow treatment*
  - *Hatchery data – # of tanks treated, tank and hatchery flow rate, the presence/absence of a settling pond*



Chloramine-T EIC Calculation

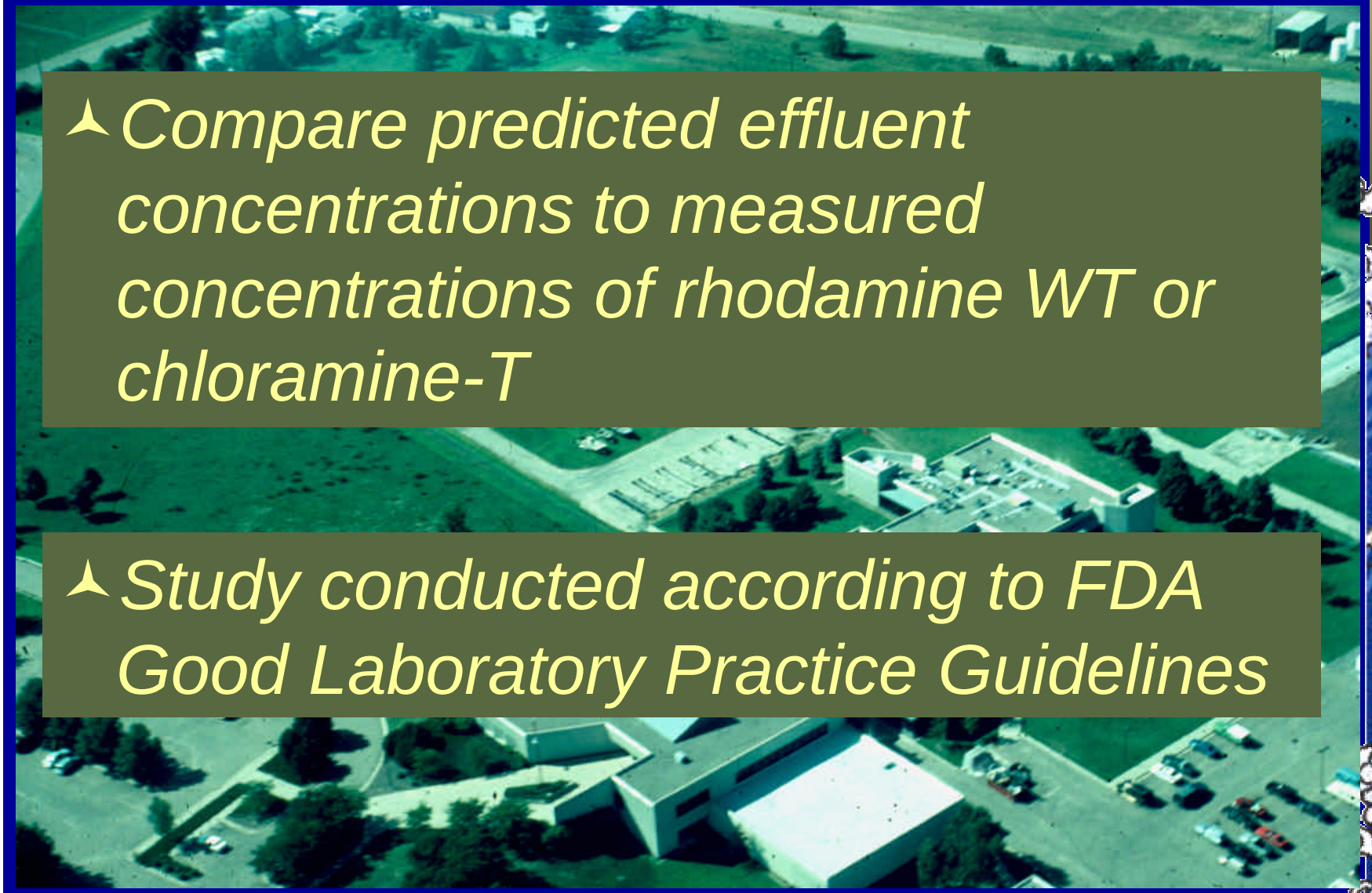
For hatcheries without settling ponds

$$\frac{\left(\text{20 mg/L} * \text{max \# of treated tanks} * \text{60 min} * \text{tank flow rate (L/min)}\right)}{\text{Hatchery flow rate (L/min)} * \text{60 min} * \text{dilution factor}}$$

For hatcheries with settling ponds:

$$\frac{\text{Mass of drug applied (mg)}}{\text{Settling pond volume}}$$

Validation of dilution model



- *Compare predicted effluent concentrations to measured concentrations of rhodamine WT or chloramine-T*
- *Study conducted according to FDA Good Laboratory Practice Guidelines*

Treatments were administered for 60 min at a raceway flow ~257 L/min; concentration was verified every 15 min in the raceway and the effluent.

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Diagram of the Upper Midwes
Center (UMESC) and wastewa
Chloramine-T and rhodamine
points along the UMESC non-

Manhole
Chemical laboratory waste manho
Non-chemical wastewater
Chemical laboratory wastewater
Combined wastewater effluent

6 Concrete ponds
12 earthen ponds (0.1-acre)
0.25-acre earthen pond
0.5-acre earthen pond
0.01-acre
R5
Concrete raceways
Sample point C
Sample point B
Small settling
Building C
Building B
Building A
Garage
Garage
Sample point A
Parking lot

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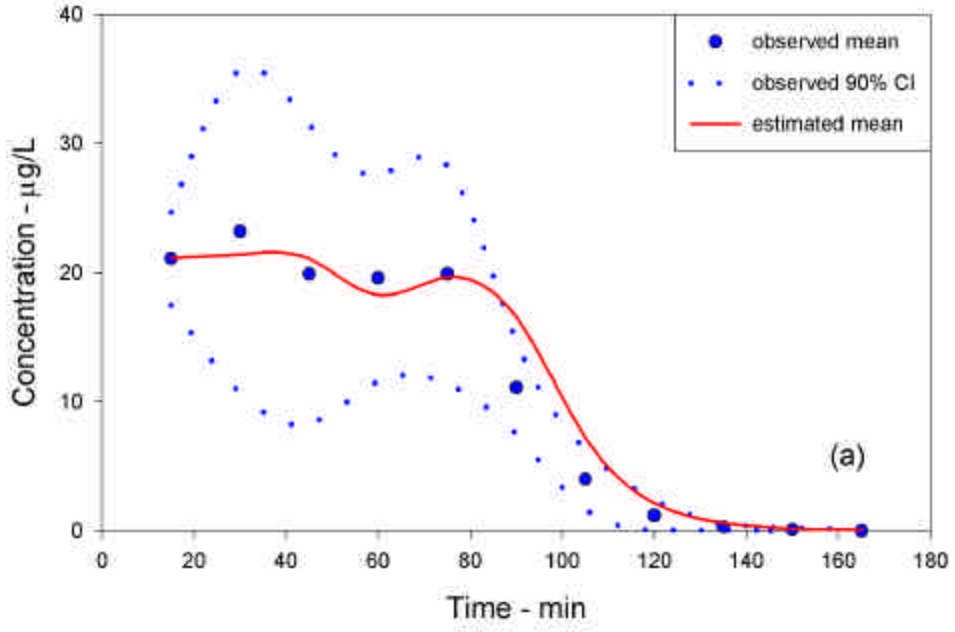
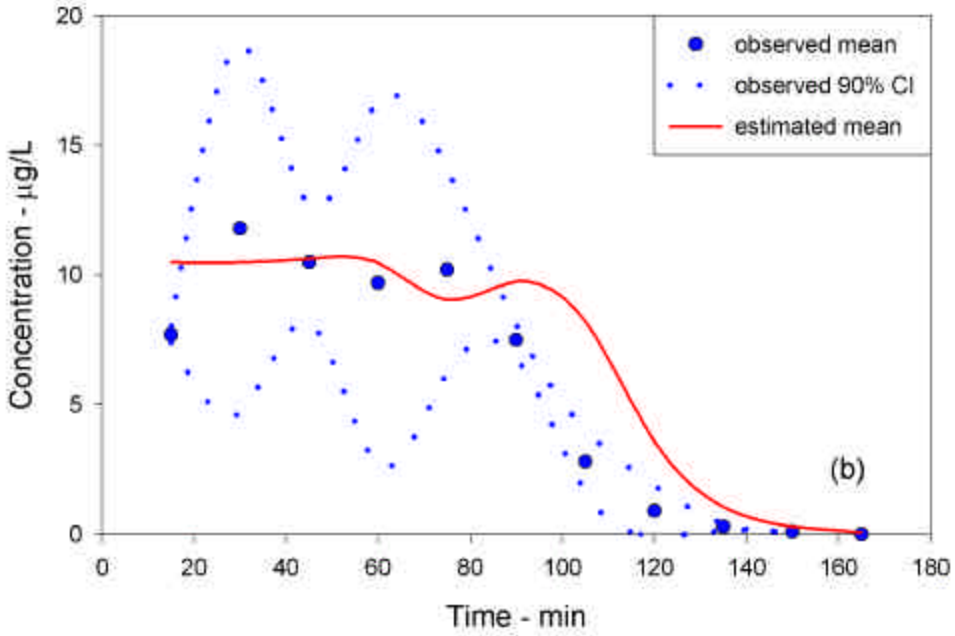
Rhodamine WT





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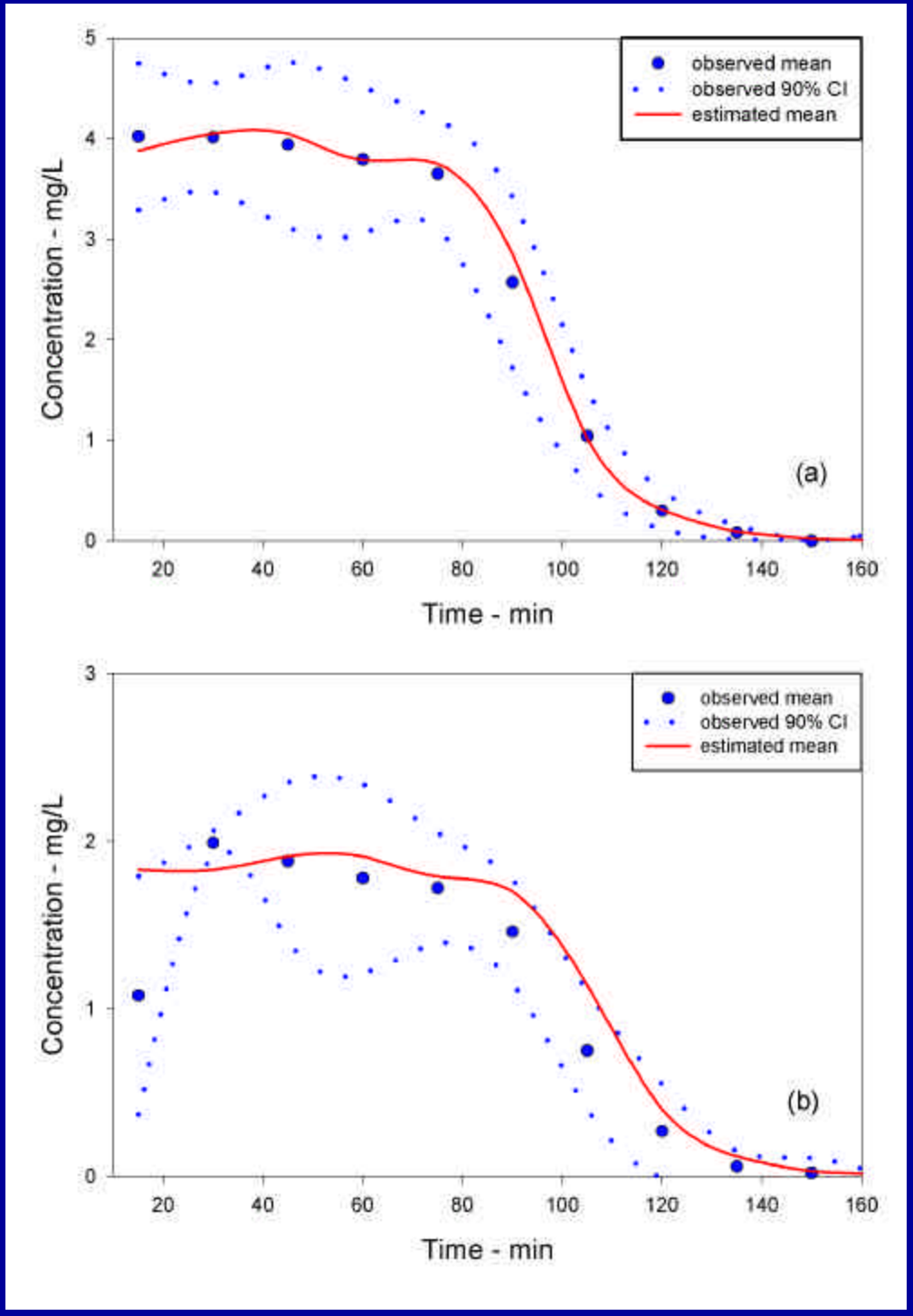
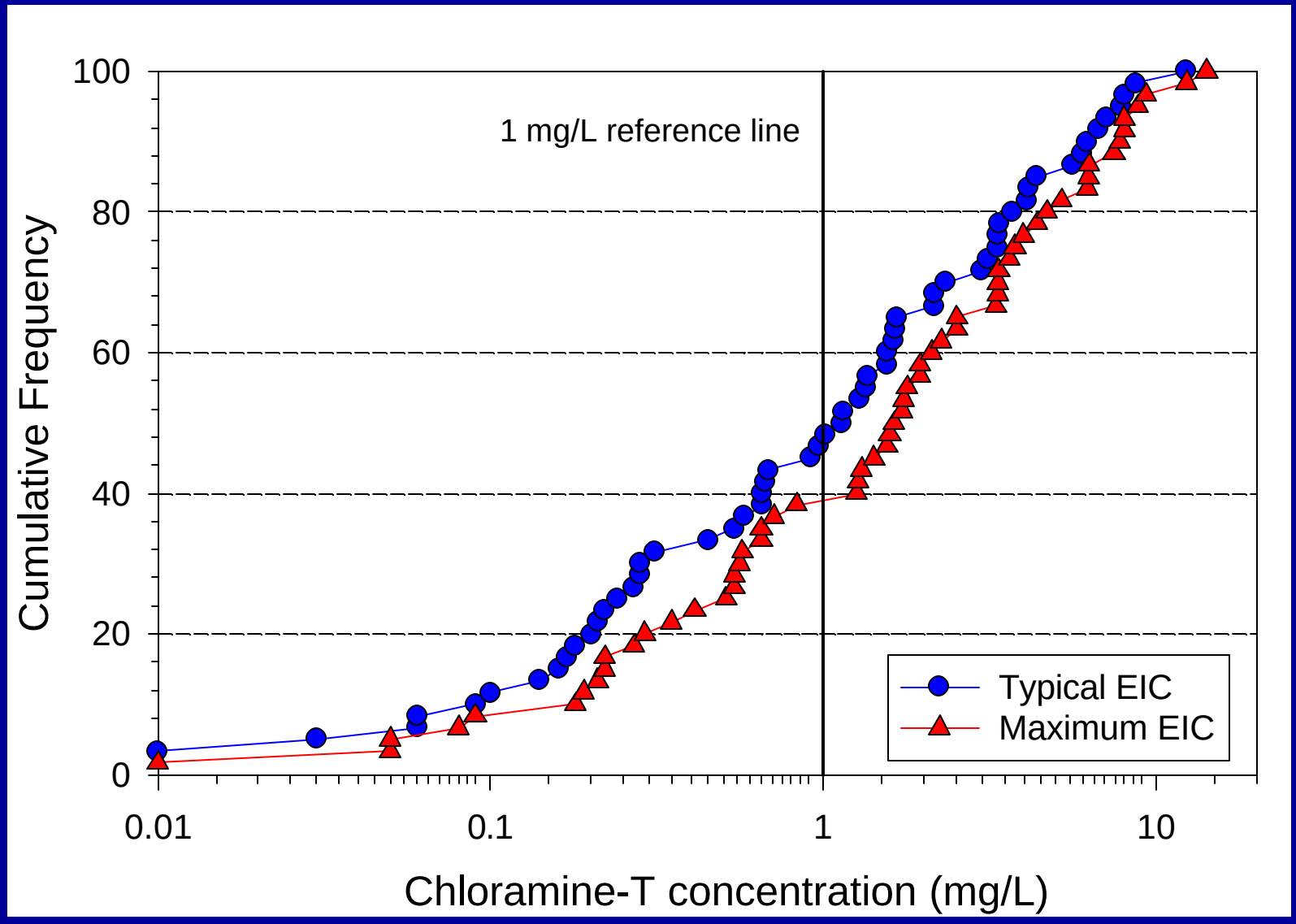
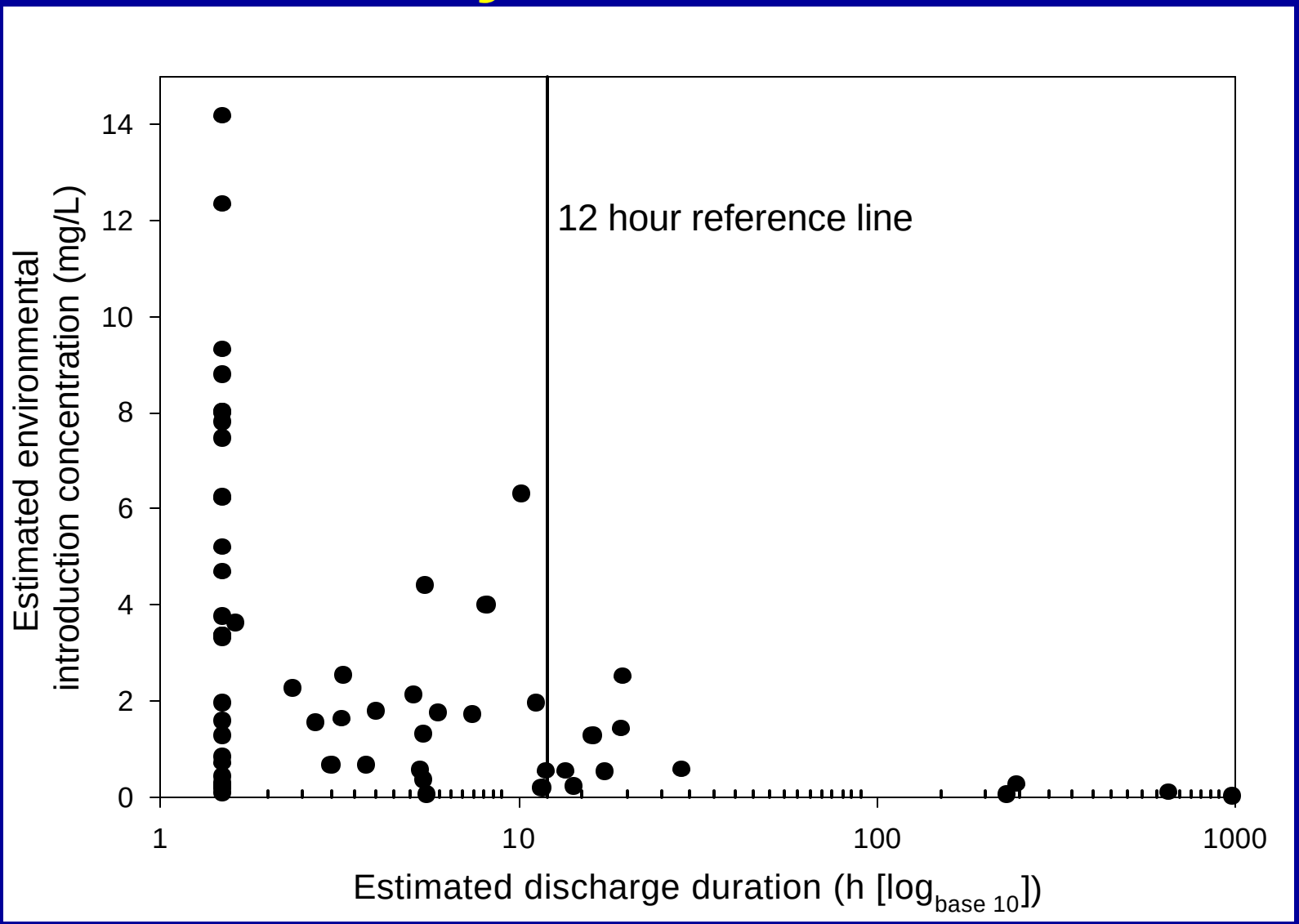
Chloramine-T



Distribution of Hatchery EICs

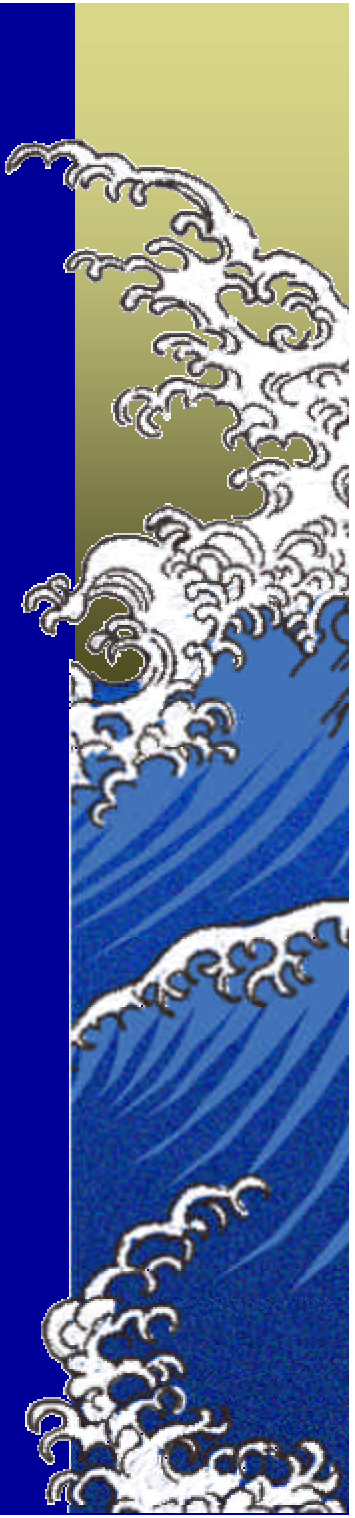


Hatchery EICs vs. Time



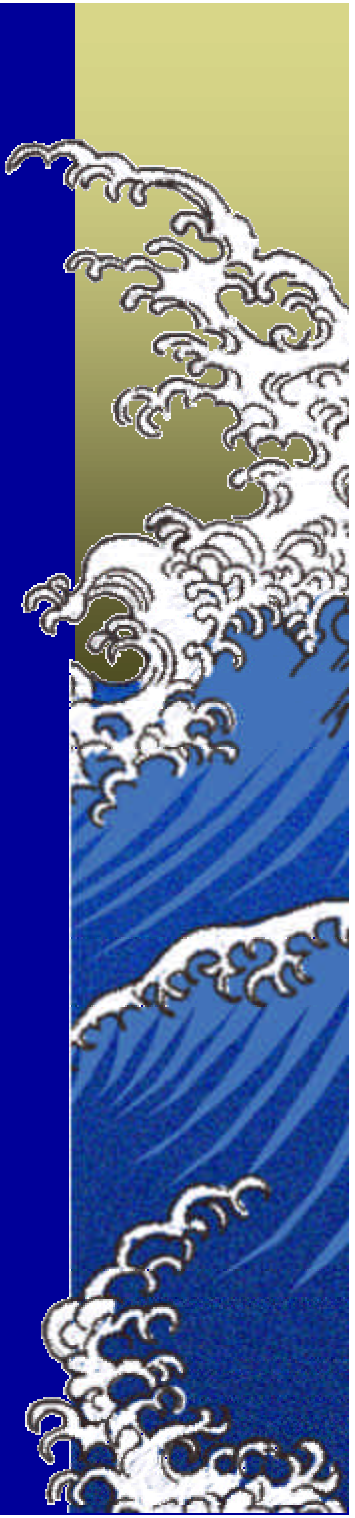
Modeling Risk

- *Discharge from most hatcheries is similar to an acute exposure.*
- *Some hatcheries could have a chronic low-level discharge – depends on the chemical and therapy*
  - *Daily egg treatments to control fungus*
  - *Large settling pond relative to flow*
  - *Medicated feeds*



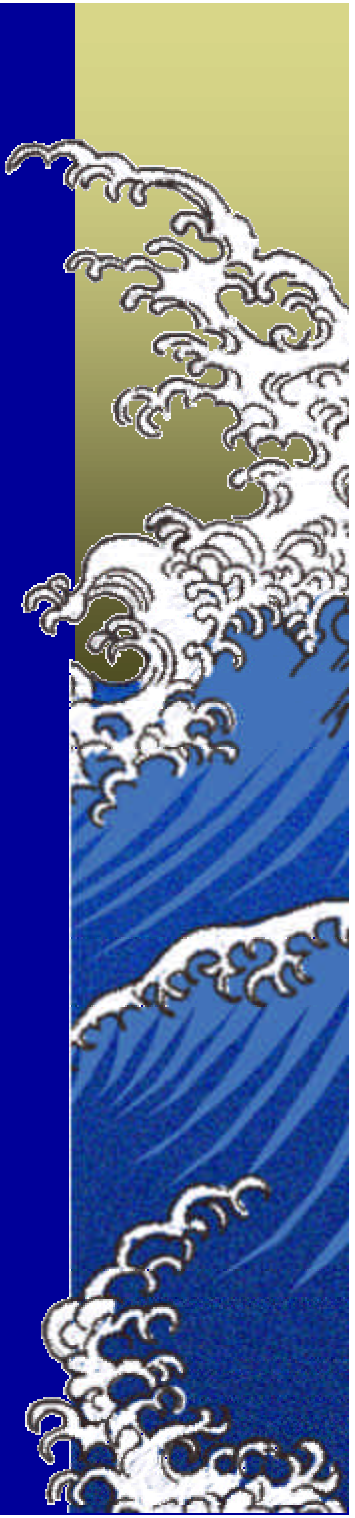
Quotient Analysis

- *Risk Quotient – acute effects*
  - *EIC divided by the No Observed Effect Concentration (NOEC) or Predicted NOEC from acute studies.*
  - *RQ of 1 to 10 – adverse effects possible.*
  - *RQ of >10 – mortality or other significant effects are possible in 50% of the population.*
- *Hazard Quotient – chronic effects*
  - *EIC divided by the NOEC from chronic studies.*
  - *HQ of > 1 indicates toxic effects are possible.*



Future work

- *Application for other contact microbicides or aquaculture chemicals*
- *Development of oral (antibiotic) drug effluent models – UW-Madison*
  - *Binding*
  - *Bioavailability*
  - *Sedimentation*
  - *Metabolism – active metabolites?*
  - *Drug resistance?*



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The Goal!!!